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Evaluation of the Effects of Sole and Combined Applications of Organic Amendments on Soil Chemical Properties and Soybean Production in Southeastern Nigeria.

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ABSTRACT

In sustainable agricultural systems, recycling of nutrients is a major component of nutrient management. A pot experiment was carried out to study the effects of sole and combined applications of pig manure and cow dung at the rates of 0, 5, 10 and 15t/ha for sole application and 1t/ha + 1t/ha, 2.5t/ha +2.5t/ha, 5t/ha+ 5t/ha and 7.5t/ha +7.5t/ha for combined application on soil chemical properties and soybean performance in Owerri West, Imo State, Nigeria. The treatments were fitted in a complete randomized design (CRD) with each rate of application replicated three times. Results showed that combined application irrespective of rates, improved the soil chemical properties than the sole application. In sole application, cow dung at the rate of 5t/ha gave the highest significant ($P \leq 0.05$) plant height, leaf area, numbers of grains and pods. Over the sampling periods, 15t/ha of pig manure gave significant ($p \leq 0.05$) higher leaf area, number of leaves, grain and pod yields than other rates. In combined application, 5t/ha +5t/ha and 2.5t/ha+2.5t/ha of cow dung and pig manure gave superior growth rate and yield components compare to other rates with the control giving the least results. On the average, 2.5t/ha+2.5t/ha rate gave higher yield components and number of leaves compared to 15t/ha of pig manure and 5t/ha of cow dung that gave improved results in sole application. The study recommended 5t/ha of cow dung and 15t/ha of pig manure for sole application, 5t/ha +5t/ha and 2.5t/ha+2.5t/ha for combined application.

Key words: Amendments, cow dung, pig manure, Soybean.

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INTRODUCTION

In recent years the focus of soil fertility research has been shifted towards the combined applications of organic amendments and mineral fertilizers as a way to arrest the ongoing soil fertility decline in Africa (Vanlauwe *et al*., 2001. Little attention has been given to the combined applications of different organic wastes which under sole applications have been proved to posses superior qualities. The organic sources can reduce the dependency on costly fertilizers by providing nutrients that are either prevented from being lost or are truly added to the system. Moreover, the continual use of mineral fertilizers without organic manures may lead to structural deterioration of the soil and increased erodibility. Combined application of the organic wastes leads to build-up of soil organic matter, thus providing a capital of nutrients resulting to improved nutrient release and uptake by crop, cation exchange and water holding capacities of soil and structural stability of soil aggregates (Idigbor and Chukwuma, 2010) and at the same time increase the soil's buffering capacity for water and acidity (De Ridder and Van Keulen, 1990).

In the tropics, soil fertility has been recognized as one of the major production constraints affecting agriculture (Omisore *et al*., 2009). According to Sanchaz *et al* (1997), soil fertility depletion in small holder farms is the fundamental cause of declining per capital food production. This depletion is mainly due to leaching, soil erosion and crop harvesting (Mba and Onweremadu, 2009), intensive and continuous cropping with low application of organic manures leading to a negative balance between nutrient supply and extraction from the soil. The need to take appropriate measures to check this decline in soil productivity is urgent, as the rate of deterioration is on the increase and if not checked will have serious implication for future food security. In view of the above, this study was conceived to investigate the potentials of sole and combined applications of cow dung and pig manure on the chemical properties of soil and soybean performance.

MATERIALS AND METHODS

The experiment was conducted at the demonstration farm of Agricultural Development Program (ADP) Ubomiri, Mbaitolu LGA, Imo State, latitude $5^0 12^1 46.45^{11}$ North and longitude $6^0 38^1 39.35^{11}$ East. Soils of the area are ultisols, low in mineral reserve and fertility, derived from

coastal plain sands (Ofomata, 1975). It is a rainforest zone with an average annual rainfall of about 2250mm and mean annual temperature varying from 21^0C to 27^0C. The predominant occupation of people in this area is agriculture, soil fertility regeneration is by bush fallowing whose length has decreased due to anthropogenic activities.

Four levels (0, 5, 10 and 15 t/ha) (sole application) and (1t/ha + 1 t/ha, 2.5 t/ha + 2.5 t/ha, 5 t/ha + 5 t/ha and 7.5 t/ha + 7.5 t/ha) (combined application) of cow dung and pig manure were factorially arranged in a complete randomized design, with each of the treatment's levels replicated four times. The soybean seeds were obtained from National Cereal Research Institute (NCRI) Amakama, Abia State, Nigeria. Four seeds were directly sowed into each of the pots, germination occurred four days after planting and seedlings were thinned to one plant per pot. Soils collected from different spots in the study area were composted, air dried and sieved through a 5 mm diameter sieve. Ten (10) kg of the soils was weighed into each of the pots; appropriate rates of the organic manures were applied based on treatments to the pots two weeks before planting, adequate moisture was supplied via overhead irrigation with the aid of watering can. Soil and organic manures used for the trial were analyzed before and after planting using standard laboratory procedures.

Plant growth was monitored in-situ from two weeks after planting using convectional growth indices such as plant height, stem girth, number of leaves and branches. However, at harvest, data on yield components, dry matter , pod and grain weights, were recorded. The data was subjected to Analysis of Variance (ANOVA), means were separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Table 1 shows the chemical properties of the soil and organic amendments before planting. The soil is slightly acidic (pH = 5.42), low in available nutrients, organic matter and base saturation. The organic amendments used were alkaline with pH 7.83 (pig manure) and 8.40 (cow dung) respectively. During microbial decomposition of incorporated soil amendments, organic acids may have been released, which neutralized the alkalinity of these amendments thus boosting the pH of the amended soil to favorable pH for optimum crop performance. Okwuagwu *et al* (2003), Somani and Totawat (1996) observed similar results in their works on the effects of organic fertilizers on soil properties. Cow dung at the rates of 5 and 10 t/ha gave higher mean values of total exchangeable bases and

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available phosphorus compared to pig manure applied at the same rates. The high concentration of available P obtained from the soil treated with cow dung may be attributed to proper mineralization of the manure resulting to P release, which is a reflection of the initial P concentration of the dung. This finding agrees with those of Salegue *et al* (2003) and Reddy *et al* (2000) that cattle manure is a potential source of phosphorus in soils and can be used as an alternative source of phosphate chemical fertilizers. The potentials of cattle manure in enhancing crop yield and ameliorating soil acidity has been demonstrated by Onwudike *et al* (2009). The total nitrogen obtained from the control before planting and after harvest are similar indicating that the crops did not absorb nitrogen from the soil, which could be attributed to the ability of soybean to fix nitrogen.

Table 1: The Properties of soil and organic amendments before the experiment.

Properties	Soil	Cow dung	Pig Manure
pH (H2O)	5.43	8.4	7.83
Org. Matter(g/kg)	24.80	167.00	123.70
Total N. (G/kg)	1.70	13.40	16.90
Av. P(mg/kg)	2.00	51.25	27.08
Ca(cmol/kg)	1.20	13.40	1.12
Mg(cmol/kg)	0.67	3.52	0.45
K(cmol/kg)	0.78	0.28	2.50
Na(cmol/kg)	0.25	0.17	0.55
TEB(cmol/kg)	2.90	17.89	4.62
EA(cmol/kg)	1.32	0.09	0.27
ECEC(cmol/kg)	4.22	17.98	4.89
	68.72	99.50	94.48

Ca = calcium, Mg = Magnesium, Na = Sodium, K = Potassium, Av.P = Available Phosphorous, BS = Base saturation, EA = Exchangeable acidity, TEB = Total exchangeable bases, ECEC = Effective cation exchange capacity of soil.

Table 2: Mean values of the effect of sole and combined applications cow dung and pig manure on soil chemical properties

Treatments	OM	TN	Av P	pH (H_2O)	TEB	EA Cmol/kg	ECEC	%B
	(g/kg)	(g/kg)	mg/kg		cmol/kg		cmol/kg	
Control	5.10	13.52	0.26	5.45	1.43	0.31	1.74	82.18
Cd 5t/ha	35.20	32.70	4.00	6.00	5.61	0.05	5.66	99.11
Cd 10t/ha	38.60	35.51	8.51	6.45	7.21	0.02	7.23	99.72
Pm 5t/ha	21.70	18.50	2.91	6.21	2.09	0.10	2.19	95.43
Pm 10t/ha	32.40	20.72	3.52	6.39	3.12	0.15	3.27	95.41
2.5+2.5t/ha	39.89	37.00	6.02	6.25	6.19	0.02	6.21	99.68
5t/ha+5t/ha	43.37	39.10	9.17	6.66	8.25	0.02	7.27	99.72

Pm = Pig Manure, Cd = Cow dung, OM = Organic matter, TN = Total nitrogen,
Av P = Available Phosphorus, EA = exchangeable acidity, TEB = Total exchangeable acidity,
TEB = Total exchangeable bases, ECEC = Effective cation exchange capacity of soil, BS = Base saturation.

However, the combined application irrespective of rates boosted the soil chemical properties compared to sole application of cow dung and pig manure. Generally, the results showed that the organic amendments improved the fertility status of the degraded ultisols used for the experiment, with the combined application giving better results (Table 2), indicating the influences of organic amendments in improving the quality of most impoverished soils of the tropics. From the results, it was ascertained that increased application rates of the animal wastes irrespective of the type, resulted to increased in the chemical properties of the soil (Table 1).

The effects of sole application of cow dung on the growth and yield components of soybean.

The effects of the sole application of cow dung on the growth and yield components of soybean are shown in Table 3. Over the sampling periods, 5t/ha rate of cow dung gave significant ($p \leq 0.05$) higher plant height, leaf area, number of grains and pods than other rates. 10 t/ha and 15 t/ha rates of application (cow dung) did not differ significantly in all the plant parameters measured at 5WAP. At 5 and 7WAP, no significant difference was recorded in the stem girth of plants irrespective of the application rates. The number of leaves, leaf area and plant height recorded at 7WAP with 10t/ha and 15t/ha rates of cow dung were similar and significantly higher than the control. At harvest, significant differences were observed in the number of grains and pods irrespective of the rate of application with the control (0t/ha) giving the least results. This finding confirms the reports of Maerere *et al* (2001), Omisore *et al* (2009) and Wright *et al* (1995) that maximum performance was obtained from plants that were treated with animal wastes relative to the untreated plant. However, the dry matter and grain weights of plant were statistically similar ($p \leq 0.05$) in all the rates, showing little or no influence of application rates on these parameters. . Generally, the trend of the effects of the rates of cow dung on the number of pods and grains was 5t/ha > 10t/ha > 15t/ha > 0t/ha. The superior effects of 5t/ha rate of cow dung indicates that exceeding this rate in soybean production may not be beneficial to farmers since the plant has inherent capacity to fix nitrogen.

The effects of sole application of pig manure on the growth and yield components of soybean.

Table 4 summarizes the results obtained from the sole application of pig manure on soybean production. At 5WAP, the number of branches, leaf area and number of leaves differed significantly in all the rates. No significant difference was recorded in the plant height and stem girth respectively. At 7WAP, all the plant parameters measured showed significant ($p \leq 0.05$) differences, except the stem girth. The 5 and 10t/ha gave similar number of flowers and branches. 5, 10 and 15t/ha rates of application gave significant higher plant height than the control, with the highest application rate (15t/ha) giving improved results at 7WAP. However, the control and 15t/ha had similar number of branches which was

Significantly higher than that recorded at 5 and 10t/ha rates respectively.

At harvest, the grain and pod yields of soybean were significantly improved by 15t/ha over other rates of application. No significant difference was observed in dry matter, pod and grain weights of plant. Unlike the cow dung, the trend of the influence of the rates of pig manure on the pod and grain yield was 15 t/ha > 5 t/ha ≥ 10 t/ha > 0t/ha. Generally, over the sampling periods, pig manure at 15t/ha gave the highest mean values of most of the parameters measured indicating that increased in the application rates of pig manure led to increased plant parameters. This finding contradicts that of cow dung application where 5t/ha rate improved most of the plant parameters, indicating the heterogeneity in agronomic potentials of animal wastes which may be attributed to the rate of mineralization and nutrient release from the animal wastes. This result was expected given the initial differences in the chemical properties of the animal manures. However, the results agreed with those of Ibeawuchi, (2009) and Maerere *et al.*, (2001) in their works on the effects of animal manure types on soil properties and crop production. The average values of the plant height, pod and grain yields obtained from the sole application of cow dung irrespective of the application rates were higher than those of pig manure, which may be due to high concentration of available P in the cow dung. Phosphorus increases nitrogen fixing ability of legumes (Attiogbevi and Somado, 2000), enhances early maturity in crops and improves the quality and quantity of grains (Idigbor and Chukwuma, 2010).

Table 3: Effects of sole application of cow dung on the growth and yield components of soybean.

	5WAP					7WAR						AT HARVEST						
Rate T/ha	Leaf area (Cm)2	NB	No. leaves	Plant height (cm)	Stem girth (cm)2	Leaf area (cm)2	NB	NF	No.of leaves	Plant hit (cm)	Stem girth (cm)	Dm (g/kg)	No.of grain	No.of pods	pod wt (g/kg)	Grain wt (g/kg)	NB	Plant ht (cm)	No.of leaves	Stem girth (cm)
Control	18.70	3.00	22.30	17.50	1.03	22.40	5.67	5.00	31.30	24.30	1.37	13,13	40.00	28.30	7.00	3.84	7.33	31.70	39.30	1.83
5	40.80	4.33	26.70	44.50	1.47	47.40	7.33	9.30	63.00	53.70	1.80	17.57	96.30	74.3	20.63	9.70	8.33	56.80	90.70	1.97
10	23.60	2.00	21.30	36.10	1.13	30.60	5.00	5.70	41.70	42.70	1.410	15.35	85.00	49.30	7.73	5.70	8.33	45.70	84.00	2.10
15	23.20	2.33	21.00	33.90	1.07	35.50	4.00	5.70	52.00	46.70	1.50	15.17	79.70	55.30	6.30	5.62	5.67	43.20	64.00	1.80
LSD 0,05	4.21	1.09	2.61	7.75	NS	9.79	NS	NS	13.64	10.80	NS	NS	5.35	3.85	3.53	NS	2.00	9.21	15.89	NS
FPr	0.034	0.04	0.050	0.003	0.112	0.004	0.55	0.49	0.006	0.003	0.400	0.555	0.035	0.014	0.002	0.235	0.050	0.039	< 0.001	0.47

No - Number, WAP = Week after planting, Ns = not significant, LSD = least significant difference, Fpr < 0.05 is significant, NB = Number of branches, ht = height

Table 4: Effects of sole application of pig manure on the growth and yield components of soybean.

	5WAP					7WAP						AT HARVEST						
Rate T/ha	Leaf area (Cm)2	NB	No. leaves	Plant ht (cm)	Stem girth (cm)	Leaf area (cm)2	NB	NF	No.of leaves	Plant ht (cm)	Stem girth (cm)	Dm wt (g/kg)	No.of grain	No.of pods	Pod wt. (g/kg)	Grain Wt. (g/kg)	Plant ht (cm)	No. of Leaves	Stem girth (cm)
0	18.70	3.00	22.30	17.50	1.03	22.40	5.67	5.00	31.30	24.30	1.37	13.13	40.00	28.30	7.00	3.84	31.70	39.30	1.83
5	24.30	0.00	15.70	24.00	1.43	36.30	3.00	10.67	41.00	31.50	1.67	17.00	65.70	52.30	9.13	4.87	36.87	107.7	1.87
10	35.40	0.00	22.00	27.00	1.23	12.00	3.67	9.67	5300	31.90	1.47	15.20	64.30	39.00	5.90	3.53	35.53	85.30	1.77
15	38.00	0.00	37.70	26.90	1.17	40.30	5.33	13.33	65.00	33.80	1.37	18.40	72.00	49.90	7.37	5.00	49.70	131.7	2.23
LSD0.05	10.80	0.99	3.60	NS	NS	17.88	1.49	5.58	9.46	7.13	NS	NS	4.42	6.57	NS	NS	3.76	26.88	0.260
Fpr	0.014	<0.001	0.034	0.210	0.532	0.027	0.012	0.052	0.024	0.029	0.470	0.637	0.030	0.019	0.629	0.788	0.020	<0.001	0.017

No - Number, WAP = weeks after planting, Ns =Not significant, LSD = least singificant difference, Fpr < 0.05 is significant, NB = Number of branches, ht = height, Dm = Dry matter, NF = Number of flowers, wt = Weight

The effects of combined application of pig manure and cow dung on the growth and yield components of soybean.

At 5 and 7WAP, significant differences were recorded in the height and leaf area of plant with 5t/ha + 5t/ha giving the highest results (Table 5). No significant difference was recorded in the number of flowers, leaves and branches at 5WAP. At 7WAP, the stem girth and number of leaves differed significantly while number of flowers and branches showed no significant difference. Unlike the sole application, combined application hastened the flowering period of soybean which started at five weeks after planting. At 5 and 7WAP, the control gave the least growth rate compared to other rates. Interestingly, 1t/ha + 1t/ha and 7.5t/ha + 7.5t/ha rates of cow dung and pig manure did not differ significantly; indicating that increased rate of combined application did not actually increase the vegetative biomass of soybean. This report contradicts those of Ibeawuchi (2009) and Omisore *et al* (2009) that increased application rate of animal wastes led to increased performance of crops in the tropics. On the average, the control irrespective of the sampling period gave the least results.

Generally, the combined rate of 5t/ha + 5t/ha and 2.5t/ha + 2.5t/ha improved the growth rate of soybean compared to other application rates, indicating that further increase of the rate to 7.5t/ha + 7.5t/ha which is equivalent to 15t/ha of sole application may not be economical and beneficial to farmers since 1t/ha + 1t/ha gave similar results to the highest combined rate.

Table 6 shows the results obtained from combined applications of the animal wastes on the yield components of soybean. At harvest, the yield components recorded from the various rates had significant differences ($p \leq 0.05$). However, the yield components recorded at the rates of 1t/ha + 1t/ha and 7.5t/ha + 7.5t/ha did not differ significantly, indicating the similarity in agronomic potentials of the two rates. On the average, the control did not improve the yield components of soybean showing the potentials of organic amendment in crop production. From the results, 2.5t/ha + 2.5t/ha and 5t/ha + 5t/ha combined rates gave higher mean values of grain weight, number of pods and grains than the highest (15t/ha) sole application rate of the manures. This reveals the superior agronomic potentials of combined application of organic amendments to sole application. This reports agreed with that of Onwudike *et al* (2009).

`Table 5: The effects of combined application rates of pig manure and cow dung on the growth of soybean.

	5WAP					7WAP					
Rates t/ha	**Leaf area (Cm)2**	**NB**	**NF**	**No.of leaves**	**Plant ht (cm)**	**Stem girth (cm)**	**Leaf area (cm)2**	**NB**	**Nf**	**No.of leaves**	**Plant ht (cm)**	**Stem gitth (cm)**
0	18.70	3.00	0.00	22.30	17.50	1.03	22.40	5.67	5.00	31.30	24.30	1.37
1+1	27.70	5.00	0.33	25.30	36.75	1.20	32.20	6.67	9.00	66.00	49.30	1.4
2.5+2.5	37.40	4.67	1.33	33.70	44.30	1.43	42.90	6.67	14.00	75.70	61.20	2.70
5+5	48.70	4.67	0.67	43.70	52.50	1.33	49.90	8.00	8.30	83.70	79.90	2.70
7.5+7.5	38.9	3.33	3.67	33.70	42.90	1.23	45.50	6.67	10.70	70.30	56.40	1.67
$LSD_{0.05}$	5.21	NS	NS	NS	8.34	NS	3.32	NS	NS	5.98	4.87	0.211
FPr	0.002	0.57	0.57	0.113	<0.001	0.072	<0.001	0.65	0.491	0.01	<0.001	0.004

No - Number, WAP = weeks after planting, Ns =Not significant, LSD = least significant Difference, FPr < 0.05 is singnificant, NB = number of branches, ht = height, NF = Number of flowers,

Table 6: The effects of combined application rates of pig manure and cow dung on the yield components of soybean.

Rates t/ha	Dry matter Weigh/plant tg/kg)	No.of grains/plant	No.of Pods/plant	Pod weight/plant (g/kg)	Grain (g/kg)	weigh/plant
Control	13.13	40.00	28.30	7.00	3.84	
1.0 + 1.0	19.00	92.70	62.70	8.81	4.67	
2.5 + 2.5	26.80	113.00	90.70	12.90	7.70	
5.0 + 5.0	33.23	127.70	108.30	14.36	9.77	
7.5 + 7.5	23.70	103.70	62.70	12.77	8.13	
$LDS_{0.05}$	5.042	10.05	9.49	3.54	3.225	
Fpr	0.002	<0.001	<0.001	0.018	0.050	

LSD = least significant difference, FPr < 0.05 is significant, No. = number

CONCLUSION

The use of organic wastes as soil amendments remains a sustainable way to improve soil productivity and enhanced food security. Results obtained from the study showed that combination of cow dung and pig manure improved the soil chemical properties, which led to increased vegetative biomass and yield components of soybean. Cow dung had superior agronomic potentials than pig manure in sole application. However, farmers are encouraged to use the combination of the various organic wastes to enhance crop production. The use of these cheap and available resources by the resource-poor farmers in the tropics will not only improve the soil properties but enhance crop production, alleviate poverty and food insecurity.

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